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ANGLE MEASURING DEVICE FOR DETERMINING ANGLE DEVIATIONS FROM A REFERENCE POSITION

[Winkelmessvorrichtung zum Erfassen von Winkelabweichungen gegenüber einer Bezugslage]

U. Ricklefs, et al.

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INVENTOR	(72):	Ricklefs, U.; Bräuer, D.
APPLICANT	(71):	Ricklefs, U.
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Description

The present invention relates to an angle measuring device for determining angle deviations relative to a reference position with a spirit level, arranged in a holder and extending horizontally in the reference position, which is filled with an optically transparent liquid and in which a gas bubble is located.

Water levels and inclination and angle measuring devices are employed in many areas of daily use. Most frequently, spirit levels are used to find the horizontal position. In such measurements, the position of a bubble in the spirit level is determined by purely visual means. These spirit levels are manufactured in large batches and are correspondingly inexpensive. Known electronic sensors typically use capacitive measuring methods, although these are too expensive for general use.

A method is known from Application DE 44 29 646 A1 that uses a spirit level for detecting the position of an object, whereby the position of the floating element is read by a light barrier unit. Only one receiver is used in this process.

Like the dependence of the radiation current of light sources on temperature, the sensitivity of radiation sensitive receivers is also temperature dependent. If two receivers were used, then the difference in the photoreceiver signals could compensate for this change, if both receivers had the same temperature response. Unfortunately, this is generally not the case even with receivers of

the same design. If the temperature is kept constant, then the two-receiver method described is advantageous. Without additional measures (temperature measurement, recording characteristic curves, and correction of the characteristic curves or temperature stabilization), however, this method is incapable of working satisfactorily over a broad temperature range.

A device is known from Patent Application DE 44 38 557 A1 for detecting angles of inclination. The device uses no spirit level, but rather half-filled containers and multiple light barriers for determining the angular position of the liquid in the container. The arrangement used is not symmetrical. Changes in temperature result in changes in the data of light source and photodiodes. Moreover, the volume of the liquid also changes with the temperature. For non-horizontal directions, the expansion of the liquid means an additional part of the receiver surface is covered by the liquid. If only one light source is used, these changes can be compensated by forming the difference in the photodiode signals, if both photodiodes deliver the same signal in the zero position (no electronic null adjustment). In general, however, the horizontal alignment does not agree with the display. Once again, the reasons for this are the different radiation sensitivities of the receivers and their different temperature response, even with components of the same design, as well as manufacturing tolerances. Electronic adjustment could not prevent a change in the zero point with temperature.

The object of the present refinement is to create a simple, cost-effective angle measuring device with high manufacturing tolerances that, nonetheless, is usable, easily operated, and precise over a broad temperature range.

This object is achieved in that the holder has an illumination unit that illuminates the spirit level and a photoelectric detector unit that receives its light, which comes from the spirit level and is affected by the gas bubble, that the illumination unit is arranged in the optical axis of the arrangement, which is fixed vertically by the axis of symmetry of the air bubble with horizontal alignment of the spirit level, over/under the gas bubble of the spirit level, that the photoelectric detector unit has paired photosensitive receivers with at least two individual receivers or integrated multi-quadrant receivers (difference diodes), which for each of the receivers of a receiver pair have a comparable sensitivity and a comparable change in sensitivity as a function of temperature, or that the photoelectric detector unit has one or more position-sensitive diodes and that the paired photoelectric receivers/position-sensitive diodes of the detector unit are arranged symmetrically to the optical axis.

The optical structure is advantageously arranged for determining the position of the bubble symmetrically to the optically active axis, so that optical aberrations that occur, such as those produced by the bubble length that are dependent on the temperature and manufacturing tolerances, have practically no effect on the measured

results. By arranging the receiver symmetrically to the optical axis, these aberrations produce signal changes that are virtually symmetrical to the optical axis. The influence of the unit-dependent change in sensitivity of the receiver with temperature is eliminated with the paired receivers or position-sensitive diodes. If only the relative signal components are examined, the individual errors are almost completely compensated. Temperature compensation is no longer needed, then, for determining the horizontal and for small measured angles.

Additional advantageous embodiments are subject matter of the dependent claims.

Additional advantages and characteristics are found in the description of several particularly advantageous exemplary embodiments below, with reference to the drawings.

In Fig. 1, the chip of a light-emitting diode **1** (LED) is reproduced slightly collimated on spirit level **3** by the glass body of the LED and an additional lens **2**. Since the light yield of infrared LEDs is particularly high, it can be useful to select LEDs of this type. Gas bubble **4** of spirit level **3** operates as a minus lens. A light spot is produced on receiver arrangement **6** by an additional lens **5**. In the arrangement shown, spirit level **3** has the shape of a barrel. This makes the light spot oblong. The position of the spot can be determined by a simple arrangement of two diodes **7**. If the spirit level is aligned horizontally, then the light spot is located

precisely in the space between diodes **7**. The measured signals of diodes **7** are subtracted by evaluation unit **10** and divided by the sum signal of the diodes. A display unit **11** emits an acoustic signal **12** or an optical signal **14** when the horizontal position is reached. Moreover, the angle to the horizontal is indicated by a digital display **13** and by the emission of an electrical signal **15**. Diodes **7** are diodes with a paired temperature response. Since selecting diodes is expensive, it is favorable to use difference diodes that are integrated on a substrate.

As Fig. 2 shows, with large-surface photodiodes the position of the spot is shifted when spirit level **3** is rotated about its longitudinal axis **8'**. However, the relative portions of the signals of the individual diodes **7** remain the same. At small angles of spirit level **3** to the horizontal, the difference in the photosignals from zero differs and can be taken as a measure of the angle. The arrangement of the two diodes **7** can also be replaced with a position-sensitive diode. The two partial signals of this diode can again be subtracted and divided by the sum signal. In case of deflection by small angles, the result differs from zero. In particular, if only the horizontal direction is to be found, the division can be omitted with no significant measurement error.

Figure 3 shows a lens-shaped spirit level **3**. The design is similar to that of Fig. 1. Here, however, the image forms a circular light spot on the detector unit. If four individual diodes **7** are

chosen, then the arrangement shown is advantageous. If spirit level **3** is in horizontal alignment to the measuring axes indicated above, the light spot is precisely in the middle, between diodes **7**. When it is inclined about one of the measuring axes **8**, **8'**, then the focal point of the light spot is shifted to one of the diodes **7**. From the difference of the mutually diagonally arranged diodes **7**, the inclination about the measuring axis perpendicular to diodes **7** can be determined. A possible assessment of the angle determination for rotation about axis **8** is shown. If the four individual diodes are replaced with a two-axis position-sensitive diode, then the situation is similar.

As Fig. 4 shows, the position of gas bubble **4** can be determined with great accuracy using a camera **9**, if for example the spot is imaged directly on the receivers or the bubble is imaged on the receivers by optics. Evaluation unit **10** then comprises an image-processing system, which the focal point of the spot or bubble and the shift can be determined.

As Fig. 5 shows, even a fuzzy image, for which no additional imaging lenses are used, provides satisfactory results. Light source **1** is a diffusely radiating surface-LED, which illuminates spirit level **3** uniformly.

Figure 6 shows a particularly advantageous arrangement of illumination unit **1** (LED) and receivers with reflection. The diffusely emitting LED is located directly under gas bubble **4** of

spirit level **3**. Photodiodes **7** are arranged symmetrically to the LED under the bubble and they detect the light reflected by the bubble. This arrangement is characterized by an extremely compact structure.

Figure 7 shows another possibility, wherein the position of the shadow produced in the border regions by bubble **4** is detected. If the bubble is shifted, then the position of shadow **16** also shifts.

A particular advantage of the measuring device in Fig. 6 is that both transmitter and receiver are located on the same side of spirit level **3**. This simplifies the wiring. Another possibility for accomplishing this is shown in Fig. 8, in accordance with Claim 15. Illumination unit **1** in the form of the light source is slightly offset relative to the receiver unit **6**. Illumination unit **1** illuminates a reflecting surface, which is located at approximately the position at which the light source is usually located.

Claims

1. An angle measuring device for determining angle deviations relative to a reference position having a spirit level (3), arranged in a holder aligned horizontally in the reference position, which is filled with an optically transparent liquid and in which a gas bubble (4) is placed, whereby the holder has an illumination unit (1) that illuminates spirit level (3) and a photoelectric detector unit (6) that receives light that comes from spirit level (3) and is affected by gas bubble (4), characterized in that,

illumination unit (1) of the spirit level is arranged in the optical axis of the arrangement, which is fixed vertically by the axis of symmetry of the air bubble with horizontal alignment of the spirit level, over/under the gas bubble (4) of the spirit level,

photoelectric detector unit (6) has paired photosensitive receivers with at least two individual receivers or integrated multi-quadrant receivers (difference diodes), which for each of the receivers of a receiver pair that is used has a comparable sensitivity and a comparable change in sensitivity with temperature, or

photoelectric detector unit (6) has one or more position-sensitive diodes and

the paired photoelectric receivers/position-sensitive diodes of detector unit (6) are arranged symmetrically to the optical axis.

2. An angle measuring device as recited in Claim 1, characterized in that an evaluation unit (10) is provided which, based on the measured signals delivered by detector unit (6), determines the angle deviation or coincidence relative to the reference position and emits it at an output unit (11, 12, 13, 14, 15) to an optical and/or acoustical and/or electrical display.

3. An angle measuring device as recited in Claim 1, characterized in that illumination unit (1) and/or detector unit (6) are adapted to spirit level (3) by optical components (2, 5).

4. An angle measuring device as recited in Claim 1 characterized in that spirit level (3) is barrel-shaped, whereby the angles about a

measuring axis (8) perpendicular to the longitudinal barrel axis and perpendicular to optical axis (0) can be determined.

5. An angle measuring device as recited in one of the previous Claims, characterized in that illumination unit (1) and detector unit (6) are arranged relative to spirit level (3) in such a way that when spirit level (3) is turned about the longitudinal axis the relative portions of the measured signals with respect to each other remain practically unchanged.

6. An angle measuring device as recited in Claim 1 or 3, characterized in that spirit level (3) is lens-like and, thus, the angles about two independent measuring axes (8, 8') perpendicular to optical axis (O) can be determined.

7. An angle measuring device as recited in Claim 6, characterized in that detector unit (6) defines mutually perpendicular base measuring axes (8, 8'), so that when the device is inclined about one of these measuring axes the relative signal portions change correspondingly only in the related measured signals.

8. An angle measuring device as recited in one of the previous Claims, characterized in that detector unit (6) is formed by large-surface receivers (7), which are arranged pair-wise symmetrical to optical axis (0), so that when the device is rotated about longitudinal axis (8') the relative measured signal portions do not change.

9. An angle measuring device as recited in one of the previous Claims, characterized in that illumination unit (1) is arranged relative to spirit level (3) in such a way that a bright spot or beam is produced on detector unit (6), which shifts when spirit level (3) is inclined about measuring axis/measuring axes (8).

10. An angle measuring device as recited in one of the previous Claims, characterized in that detector unit (6) is arranged relative to illumination unit (1) and spirit level (3) in such a way that the radiation from the light source is partially shadowed by the bubble and the shadow shifts when measuring axis/measuring axes (8) are inclined.

11. An angle measuring device as recited in one of the previous Claims, characterized in that detector unit (6) is a camera (9).

12. An angle measuring device as recited in one of the previous Claims, characterized in that output unit (11) emits an acoustical signal (12) or optical signal (14), from which the deviation from the horizontal can be determined.

13. An angle measuring device as recited in one of the previous Claims, characterized in that the output unit emits an optical signal (13), from which the angle to the horizontal can be determined.

14. An angle measuring device as recited in one of the previous Claims, characterized in that output unit (11) emits an electrical signal (15), from which the angle to the horizontal can be determined.

15. An angle measuring device as recited in one of the previous Claims, characterized in that illumination unit (1) is replaced with a mirroring or reflecting surface, by which the light of a light source (16) is coupled into the measuring beam path.

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4 pages of figures attached.

ZEICHNUNGEN SEITE 1

Nummer: DE 198 54 812 A1
Int. Cl.[6]: G 01 C 9/24
Offenlegungstag: 26. August 1999

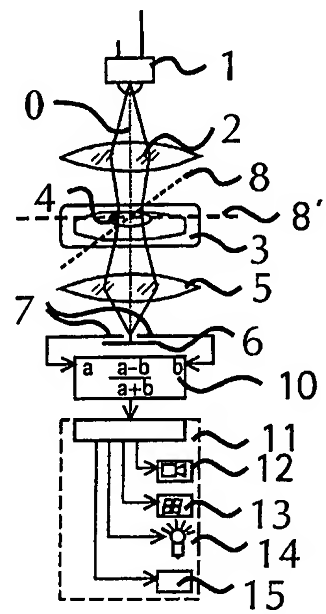

Fig. 1

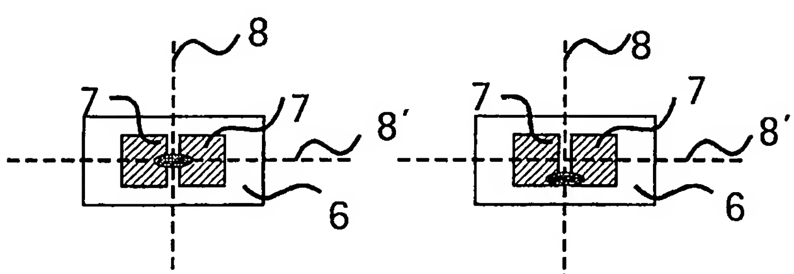

Fig. 2

902 034/545

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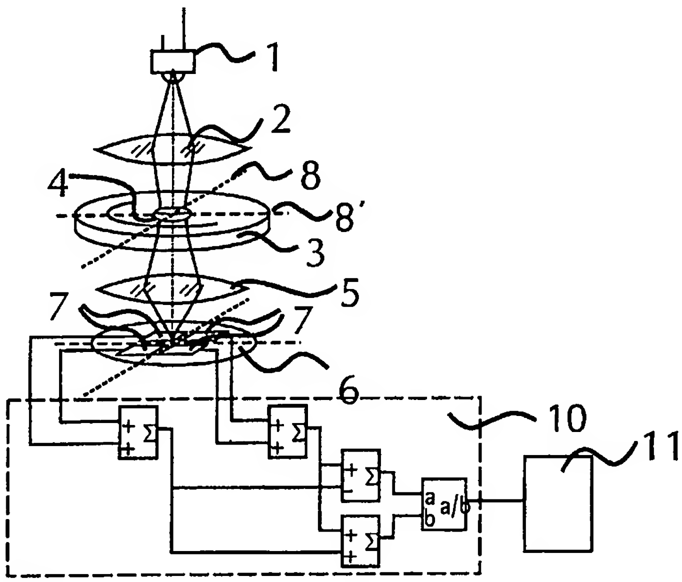

Fig. 3

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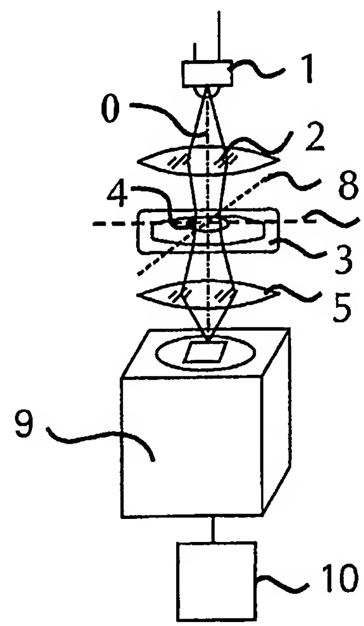

Fig. 4

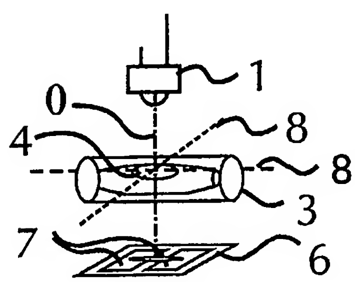

Fig. 5

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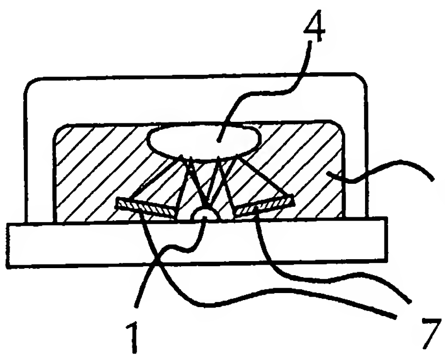

Fig. 6

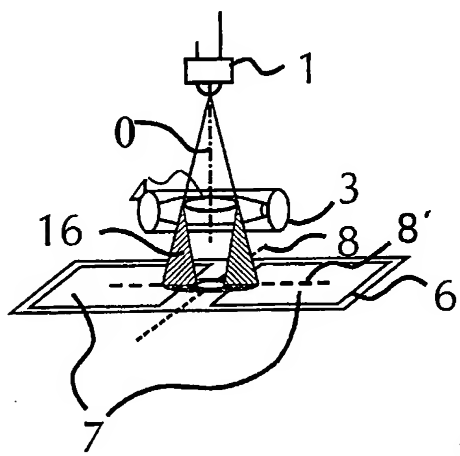

Fig. 7

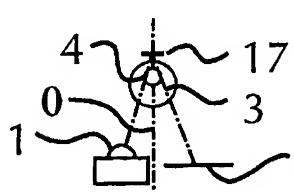

Fig. 8